SURVEY OF RURAL INFORMATION INFRASTRUCTURE TECHNOLOGIES

U.S. DEPARTMENT OF COMMERCE
Ronald H. Brown, Secretary

Larry Irving, Assistant Secretary
for Communications and Information, and
Administrator, National Telecommunications
and Information Administration

September 1995

PREFACE

The mission of the National Telecommunications and Information Administration (NTIA) is to promote the technological development and economic competitiveness of the U.S. telecommunications and information industries in order to benefit the people of the United States. Among its many activities, NTIA oversees the Telecommunications and Information Infrastructure Assistance Program (TIIAP).

TIIAP supports National Information Infrastructure (NII) planning activities and demonstration projects at the grassroots level throughout the Nation, and provides a partnering model that accelerates development of the NII by leveraging private investments with limited Federal dollars. In 1994, TIIAP provided $24.4 million for 92 grants in 45 states and the District of Columbia to plan, test, and/or stimulate NII activities by non-profit institutions (school districts, public libraries, local governments, etc.). Project partners contributed $40 million in matching funds, resulting in a total investment in public infrastructure of $64.4 million.

The Institute for Telecommunication Sciences (ITS) is the chief research and engineering arm of NTIA. ITS has prepared this report in support of the objectives of TIIAP. It is available electronically through the ITS Home Page on the World Wide Web at http://www.its.bldrdoc.gov. More information about ITS, NTIA, and TIIAP can also be found by visiting this Web site.

Certain commercial systems, equipment, and services are identified in this report. In no case does such identification imply recommendation or endorsement by NTIA, nor does it imply that any of these systems, equipment, or services are the best available.

ACKNOWLEDGMENTS

CONTENTS

EXECUTIVE SUMMARY

It is a top priority of the Clinton Administration to develop an advanced National Information Infrastructure (NII) that will deliver to all Americans the information they need when they want it and where they want it, at an affordable price. Extending the NII into inner cities and rural areas is of particular concern to the Administration. In an April speech at Educom's National Net '95, Larry Irving, Assistant Secretary for Communications and Information, U.S. Department of Commerce, stated

> We believe the following four goals are essential to promote universal and equitable access to the NII: (1) preservation and advancement of the concept of universal service, (2) promotion of community partnerships, (3) continued support for universities and research institutions, and (4) outreach to underserved communities...We need to ensure that inner city and rural residents are informed about the opportunities that exist and the best ways of harnessing them for their communities. These communities need to know what technologies and applications are available, what existing infrastructure they have and need, and what has worked for similar communities.

The Rural Information Infrastructure (RII) is the part of the NII that will reach into America's rural areas, providing access to a broad range of information and information services. The purpose of this report is to contribute to the development of the RII by

- defining a set of distinct voice, computer, and video telecommunication services.
- describing rural information applications that make use of these services.
- surveying various wireline and wireless systems and technologies that are being used or might be used to deliver these services to rural areas.

Telecommunication Services and Information Applications

The approach taken in this study to analyze the availability of technologies for the RII begins with the definition of a set of telecommunication services. These services, listed below, represent major classes of telecommunication capabilities that already exist or are expected to become available in urban areas as the NII evolves:

- Two-way Voice
- Multiple-way Voice Teleconferencing
- Multiple-channel Audio Programming
- Low-speed Computer Networking
- Medium-speed Computer Networking
- High-speed Computer Networking

- Very High-speed Computer Networking
- Video Conferencing, Lossy
- Video Conferencing, Broadcast Quality
- Multiple-channel Video Programming
- Video on Demand
- Interactive Video.

Rural information applications include electronic mail, remote access to computer-based data, distance learning, local area network interconnection, electronic commerce, and electronic government. This list of applications is meant to be illustrative rather than exhaustive; creative users are constantly devising new ways to apply information technology. The key point is that

to support a range of important and beneficial information applications, rural users require access to a wide variety of telecommunication services.

Wireline and Wireless Systems and Technologies

A number of wireline and wireless systems and technologies may be able to deliver telecommunication services to rural areas. These include

Wireline: Public Switched Telephone Network
           Cable Television
           Computer Communication Networks.

Wireless: Land Mobile Radio
           High Frequency (HF) Radio
           Terrestrial Broadcasting
           Multichannel Multipoint Distribution Service
           Wireless Telephone Systems
           Radio Paging
           Packet Radio
           Wireless Local Area Networks
           Wireless Digital Modems
           Satellite Systems.

The capabilities of these systems and technologies vary considerably, as does the degree to which they are or can be made available in rural areas.

Conclusions

The following general conclusions can be drawn concerning the development of the RII:

- It is desirable to have access to telecommunication services in rural areas that approaches that available in urban areas.

- Distance and low population density are the distinctive features of rural areas affecting telecommunications. These factors increase the costs of providing telecommunication services. In addition, systems and technologies developed for urban areas may be less than optimal for rural areas.

- The distances involved in living in rural areas increase the benefit and therefore value of telecommunication services. Telecommunication enables applications such as distance learning that can alleviate or eliminate some rural disadvantages. Telecommunication can make rural areas more attractive for some businesses and result in revitalization of the rural economy.

- The effects of deregulation on rural areas are less certain than on urban areas and should be carefully watched by regulators. Rural areas may not be able to support several competitive service providers. Multiprovider markets should be developed wherever feasible in both urban and rural areas as a means to reduce costs and spur innovation. Where a given market fails and only a monopoly service provider exists, policymakers should prescribe appropriate regulations to protect the public interest.

- Historically, the deployment of telecommunication capabilities in rural areas has been delayed relative to deployment in urban areas. This has been due to the inability of rural areas to compete with urban areas for capital, since rural areas do not offer as high a return on investment. Telephone cooperatives have proven to be effective in accelerating the deployment of new technology. Telecommunication cooperatives could be an effective way of reaching rural areas with the NII.

- Government regulations and policies will play an essential role in the development of the RII. Different regulations and policies will likely be required in rural areas than in urban areas.

- The technical deployment of advanced telecommunication capabilities may not be very different in small towns than it is in urban areas. Reaching isolated homes and businesses in farming areas and especially remote desert and wilderness areas will be difficult, and will require technology deployments different from that in urban areas.

The following conclusions can be drawn concerning the assessment of technologies to support the RII:

- Numerous technologies can support all of the voice and audio telecommunication services. In many cases, those technologies are available to rural consumers today and competition by various providers may be viable.

- Numerous technologies are available in rural areas to provide low-speed computer networking service, such as dial-up access to computer networks via the PSTN. As demand increases for faster transmission speeds, current implementations of technologies will prove inadequate to meet that demand.

- High-speed and very-high speed computer networking services could effectively support the transmission of voice, data, and video information. Theoretically, a single infrastructure could be used to extend the NII into rural areas. Technical, regulatory, and economic barriers, however, may render this impractical.

- No technologies presently support all of the video telecommunication services. Video programming is provided in rural areas by terrestrial broadcasting, cable TV, and satellite broadcasting. In more remote regions, however, only satellite broadcasting provides video programming on a par with that available in urban areas. Video conferencing can be provided over switched digital circuits or narrow-band ISDN and is available in some rural areas. Video on demand and interactive video are planned

but will be provided by select technologies that probably cannot economically reach farms, ranches, and isolated homes.

- It is likely that new technology will need to be developed to economically deliver advanced computer networking and video services to individual farms, ranches, and isolated homes. A wireless technology will most likely be required, and certainly the most remote users can only be reached by wireless technology.

SURVEY OF RURAL INFORMATION INFRASTRUCTURE TECHNOLOGIES

Kenneth C. Allen, Robert J. Achatz, Brent L. Bedford, Eldon J. Haakinson, Raymond D. Jennings, Michael G. Laflin, Vincent S. Lawrence, John J. Lemmon, Patricia J. Longstaff, Robert J. Matheson, Elizabeth E. Pol, Bradley J. Ramsey, Wayne R. Rust, Frank S. Sanders, Robert B. Stafford, Jeffery A. Wepman[*]

ABSTRACT

Communication and information technologies can reduce the barriers of distance and space that disadvantage rural areas. This report defines a set of distinct voice, computer, and video telecommunication services; describes several rural information applications that make use of these services; and surveys various wireline and wireless systems and technologies that are being used or might be used to deliver these services to rural areas. Rural information applications require a wide range of telecommunication services, but no current system or technology is capable of delivering all of these services to all areas. This report concludes that there are many technologies suitable for providing voice telecommunication services in rural areas. It is also technically feasible to provide advanced computer networking and video capabilities to even relatively small towns in rural areas. No technology was found capable, however, of economically providing these broadband capabilities to the most isolated farms, ranches, and homes. It is expected that new wireless technology will need to be developed to accomplish this. Government regulations and policies will also play an essential role in the development of the Rural Information Infrastructure. Different regulations and policies will likely be required in rural areas than in urban areas.

Key words: National Information Infrastructure (NII); networking; Rural Information Infrastructure (RII); rural telecommunications; telecommunication services; telecommunication systems; telecommunication technologies

_____

[*] The authors, with the exception of Elizabeth E. Pol, are with the Institute for Telecommunication Sciences, National Telecommunications and Information Administration, U.S. Department of Commerce, Boulder, Colorado 80303. Ms. Pol was formerly with the Institute.

INTRODUCTION

Many of America's rural areas show signs that raise concern for their future: loss of economic vitality, a relative decline in income, high unemployment, low workforce participation, and an exodus of talent. Advances in communication and information technologies, however, can reduce the barriers of distance and space that disadvantage rural areas (Office of Technology Assessment, U.S. Congress, 1991).

Gregory Lawrence (1994), in a paper that was presented at the U.S. Agricultural Information Network National Conference, expands on this point:

> The economic, educational, and social needs of rural America are complex, diverse, and dynamic. Rural communities are trying to cope with intense global competition for agricultural markets, a declining industrial base, an aging population, and the need for better schools, health care, and human services. These problems are aggravated by the fact that rural America is information poor. Using almost any scale of measurement—radio and television market access, numbers and sizes of libraries, newspapers, bookstores, schools—rural counties trail urban and suburban areas in delivery of information goods and services. This information poverty threatens a further decline in the precarious economic health of rural America. In a transformed world economy, driven by information exchange, isolation becomes irrelevance.

A study published by the Organization for the Protection and Advancement of Small Telephone Companies (OPASTCO, 1994) concludes, "Telecommunications could serve as a lifeline piping in the quality education, health care, and jobs crucial to maintaining rural communities as vital production components of the national economy, but rural subscribers and communities will not be able to take advantage of these benefits if access to telecommunication services is priced beyond their reach."

It is a top priority of the Clinton Administration to develop an advanced National Information Infrastructure (NII) that will deliver to all Americans the information they need when they want it and where they want it, at an affordable price. Extending the NII into inner cities and rural areas is of particular concern to the Administration. According to Larry Irving, Assistant Secretary for Communications and Information, U.S. Department of Commerce (1995),

> We believe the following four goals are essential to promote universal and equitable access to the NII: (1) preservation and advancement of the concept of universal service, (2) promotion of community partnerships, (3) continued support for universities and research institutions, and (4) outreach to underserved communities…We need to ensure that inner city and rural residents are informed about the opportunities that exist and the best ways of harnessing them for their communities. These communities need to know what technologies and applications are available, what existing infrastructure they have and need, and what has worked for similar communities.

The Rural Information Infrastructure (RII) is the part of the NII that will reach into America's rural areas, providing access to a broad range of information and information services.

1.1 Purpose and Scope

The purpose of this report is to contribute to the development of the RII by

- defining a set of distinct voice, computer, and video telecommunication services.
- describing rural information applications that make use of these services.
- surveying various wireline and wireless systems and technologies that are being used or might be used to deliver these services to rural areas.

Numerous references are cited as sources for additional information. Appendix A contains a list of acronyms and abbreviations used in this report. Appendix B summarizes the results of Institute for Telecommunication Sciences (ITS) measurements of rural radio spectrum usage in Eureka, California.

This report is intended to serve as a resource for

- Federal, state, and local legislators, regulators, economic development officials, and other policy makers.
- providers of telecommunication services to rural areas.
- rural users of telecommunication services, including schools, libraries, health care organizations, businesses, local governments, and individuals.

1.2 Defining Rural Areas

Farms, ranches, and small towns are all intuitively associated with rural areas. Such intuition grasps the fundamental characteristic of rural areas, low population density. It is useful, however, to explore a statistical description used by the Office of Management and Budget (OMB) to help gain an increased understanding of how much of America can be considered rural.

OMB divides the United States into county-based Metropolitan Statistical Areas (MSAs) and nonmetropolitan areas. A county is included in an MSA if

1) it contains a city with a population of at least 50,000; or
2) it contains an urbanized area[1] with a population of at least 50,000 and a total metropolitan population of at least 100,000; or
3) it has strong economic and social ties to a central county containing the main city or urbanized area.

For example, the Colorado Springs, Colorado MSA includes a single county with a single large city. The Indianapolis, Indiana MSA includes a single large city located in Marion County, but it also includes eight surrounding counties that are relatively densely populated. The Las Vegas, Nevada MSA includes a single large city located in Clark County, but it also includes sparsely

---

[1] According to the Census Bureau, an urbanized area consists of a central city and the contiguous, closely settled area outside the city's political boundaries.

populated Nye County. Ten counties in the state of Iowa are included in MSAs, but the remaining 89 counties are considered nonmetropolitan. Figure 1-1 shows the areas of the continental United States designated as MSAs.[2]
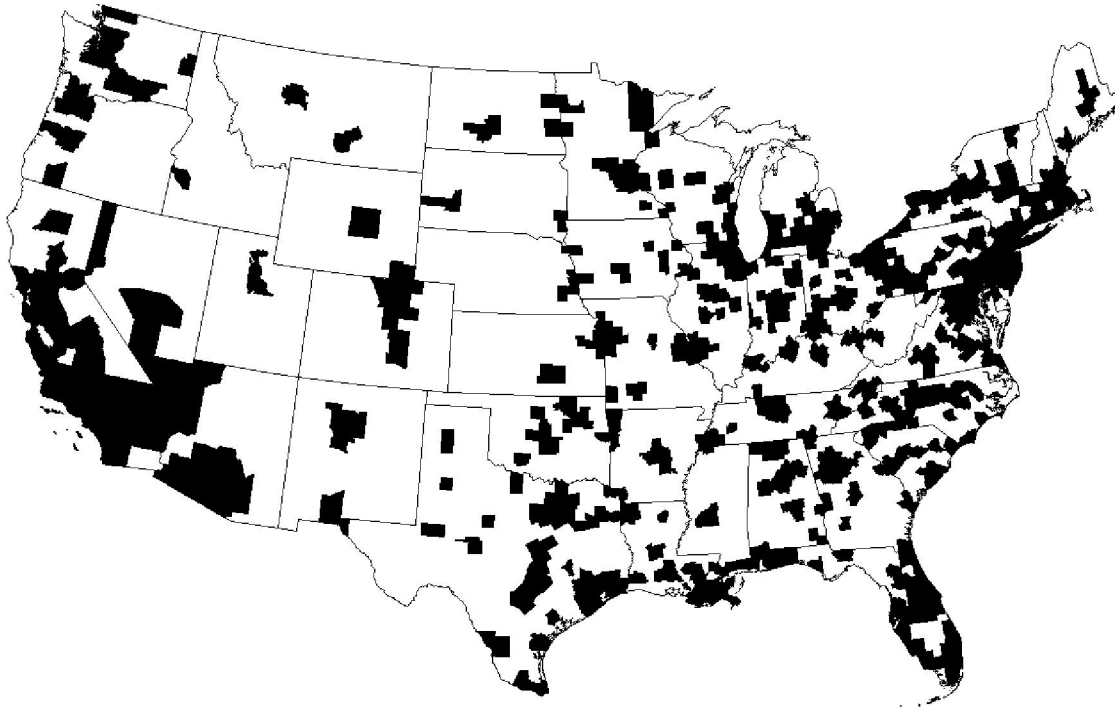
Figure 1-1. Metropolitan Statistical Areas in the continental United States. (Source: U.S. Bureau of the Census, 1990).

According to 1994 population estimates, approximately 80% of the total U.S. population of 259.6 million people live in MSAs (Rand McNally, 1995). The remaining 20%, 52.4 million people, live in nonmetropolitan counties. Nonmetropolitan counties, however, comprise approximately 80% of the land area in the country (U.S. Bureau of the Census, 1994).

Some counties included in MSAs contain portions that are sparsely populated and located a considerable distance from the nearest city. Many of these areas do not have a telecommunication infrastructure adequate to support the information needs of local school districts, libraries, health care providers, businesses, governments, and private citizens. For the purposes of this report, we adopt a broad definition of rural areas that includes not only nonmetropolitan counties, but also sparsely settled and distant portions of MSAs.

---

[2] MSAs in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, andVermont are defined in terms of cities and townships rather than counties.

It is important to note also the diversity inherent within the socioeconomic fabric of rural areas (Sawhney, 1992). A close look reveals significant differences in topographic features, natural and human resources, population distribution, economic activities, and cultural norms.

TELECOMMUNICATION SERVICES AND RURAL INFORMATION APPLICATIONS

This section defines voice and audio, computer, and video telecommunication services that are of interest to rural users. It also describes applications that make use of these services to help schools, libraries, health care organizations, businesses, governments, and individuals in rural areas access and deliver information more effectively.

The telecommunication service definitions are generic; they do not specify particular technologies. Rural information applications can thus be discussed in terms of the services they require rather than specific technologies. After the survey of wireless and wireline technologies in Sections 3 and 4, Section 5 compares the various technologies in terms of the services that they can deliver.

2.1 Voice and Audio Telecommunication Services

The frequency components of human speech typically range from 100-6,000 Hz, but most of the speech energy is contained between 300 and 3,300 Hz (Rowe, 1988). Hence, a 3,000-Hz bandwidth is required to accommodate voice telecommunication. The human ear can typically hear frequencies from 50-15,000 Hz, so a bandwidth of approximately 15 kHz is required to accommodate high-quality audio telecommunication services. Voice and audio telecommunication services include the following:

Two-way Voice, Fixed. This service allows two users to communicate by voice using fixed transceivers.

Two-way Voice, Mobile/Portable. This service allows two users to communicate by voice when one or both of them are able to move about (within certain spatial limits). The voice transceivers may be mounted in a vehicle (mobile) or handheld (portable).

Multiple-way Voice Teleconferencing. This service is an extension of two-way voice service, and allows multiple users at different locations to communicate by voice. It is largely a function of telecommunication network control and switching capability. Voice transceivers may be fixed, mobile, or portable. One user may speak to many listeners, and each listener is also able to become the speaker.

Multiple-channel Audio Programming. This service allows users to choose from among several audio programs for educational, informational, or entertainment purposes. The user is not able to interact with the information provider to make programming or scheduling changes in real time.

2.2 Computer Telecommunication Services

Computer telecommunication services facilitate communication between computers or terminal devices. A transmission may consist of only a few hundred bits to send an electronic mail message, or it may consist of several million bits to send a single complex image. Successful transmissions depend on well-defined conventions (protocols) which govern the format and timing of information exchange. The protocols include mechanisms to detect and correct bit errors, which may occur due to a variety of factors.

One-way communication or broadcasting of data is adequate for some applications. One example is the broadcasting of stock market data to handheld receivers. Another example is the future broadcasting of road, weather, and traffic conditions to vehicles. Such wireless broadcasting of data can most economically be provided through the use of radio and television broadcasting facilities; these technologies are discussed in Section 4. Because of the close relationship between data broadcasting and traditional broadcasting technology, data broadcasting is not included in the set of computer telecommunication services defined here.

Different applications require different levels of computer telecommunication service performance to provide adequate response to users. Factors that affect performance include transmission speed (measured in bits per second; bps), type of network switching, type of network protocol, and degree of network loading. For the purposes of this report, services are categorized below based on transmission speed:

Low-speed Computer Networking, Fixed. This service allows fixed computers or terminal devices to communicate at transmission speeds less than 56 kbps.

Low-speed Computer Networking, Mobile/Portable. This service allows mobile or portable computers or terminal devices to communicate at transmission speeds less than 56 kbps.

Medium-speed Computer Networking. This service allows fixed computers or terminal devices to communicate at transmission speeds from 56 kbps to 2 Mbps.

High-speed Computer Networking. This service allows fixed computers or terminal devices to communicate at transmission speeds from 2-45 Mbps.

Very High-speed Computer Networking. This service allows fixed computers or terminal devices to communicate at transmission speeds above 45 Mbps.

2.3 Video Telecommunication Services

Digital video applications are among the most demanding in terms of the bandwidth required and the time sensitivity of the information. Traditional broadcast-quality video transmission requires a bandwidth of several megahertz. Digital compression/decompression techniques are

increasingly used to reduce this requirement, but such techniques may result in a loss of spatial or temporal resolution.[1] Video telecommunication services include the following:

Video Conferencing, Lossy. This service allows users at two or more locations to communicate by both sound and sight. Multiple video monitors may be used at each site, or users may monitor a single site for video and listen to only the audio from other sites. Another variation is to distribute a video signal to many sites and return only audio from these sites. Transmission speeds of less than 2 Mbps accommodate only highly compressed video signals. Motion in the received video is typically perceived as a series of distinct snapshots (jerky) rather than as smooth and continuous, moving objects may be characterized by reduced sharpness of edges and reduced spatial detail (smearing), and the entire image may be blurred. The level of video impairment will vary depending on the content of the source and the compression/decompression algorithms used. Video provided through voice-bandwidth channels has not been widely accepted. Advances in compression technology are eventually expected to result in improved video quality at low transmission speeds, but the timetable for these advances is uncertain.

Video Conferencing, Broadcast Quality. This service allows users at two or more locations to communicate by both sound and sight. Transmission speeds ranging from 2-45 Mbps still require compression/decompression of the video signals, but the video images are generally broadcast-quality or better.

Multiple-channel Video Programming. This service allows users to choose from as many as several hundred broadcast-quality video programs for educational, informational, or entertainment purposes. The user is not able to communicate directly with the video provider to make programming or scheduling changes.

Video On Demand. This service allows users to select a video program to view and the time that the program will be delivered. User communication with the video provider may be over the same telecommunication system that delivers the video. Once the video programming starts, however, the user has no more control over program delivery.

Interactive Video. This service is similar to video on demand, but users have additional capabilities. The simplest form of interactive video allows users to stop, rewind, fast forward, and freeze the motion of the video program as it is delivered. A more versatile form of this service allows users to interact with the video program at various prompts. For example, if the video program were an educational presentation on cooking, users might be allowed to select from cooking entrees, side dishes, or desserts. If a user selected entrees, the program might then offer new options, like preparing fish, beef, or pork entrees. With interactive video, users can control the delivery of the video program and make real-time selections of content.

---

[1] See the Rural Multimedia Quality of Service Handbook, a multimedia compact disc published by ITS, for definitions of terms that describe video performance. The Handbook also contains video clips which illustrate impairments that may be associated with digital video compression techniques.

2.4 Rural Information Applications

The telecommunication services identified above can be used in a variety of ways to enhance information access and delivery in rural areas. Key rural information applications include electronic mail, remote access to computer-based data, distance learning, local area network (LAN) interconnection, electronic commerce, and electronic government.

2.4.1 Electronic Mail

Electronic mail allows individuals to exchange messages over a network with other individuals or groups. Messages may include text, images, appended files, even audio or video clips, depending on the implementation of the mail application. Users may send or retrieve messages at their convenience, thus avoiding the interruption of a telephone call or the frustration of "telephone tag." Sending a message does not involve traveling to a post office or preparing an envelope, and delivery is quick, usually within minutes.

Electronic mail could allow students in a rural school to exchange information with peers or subject matter experts in other towns, states, or countries. It could allow a rural physician to confer with a specialist in a large metropolitan area, or to broadcast a reminder to parents about teaching proper hygiene to their children during cold and flu season. A rural business could establish an electronic mail "hotline" to take and respond to questions from customers.

An electronic mail application requires relatively little in terms of telecommunication services. Messages are typically short and are not expected to be delivered in real or near-real time. Low-speed computer networking service is adequate; in addition to fixed capability, rural users will likely be interested in mobile/portable capability to allow communication with those whose work takes them out of a traditional office environment.

2.4.2 Remote Access to Computer-based Data

Remote access capability allows rural users to log on to bulletin board systems, subscribe to commercial on-line services, or tap the resources of the Internet (including the World Wide Web).[2] In each case, a different local software configuration is required. The quantity of information available from remote sources varies, but remote users are typically able to

- browse documents, images, and databases on a variety of topics.
- transfer files to or from the remote system.
- submit data and run programs on a remote system; receive program output.
- participate in on-line forums or discussion groups on specific topics (may be live).
- send and receive electronic mail messages.
- shop for goods and services.

---

[2] Commercial on-line services provide varying levels of Internet access in addition to their other offerings.

Remote access could allow rural students to search the Library of Congress and other on-line sources for the latest information on a topic. A rural physician could consult an on-line database to help diagnose a difficult case or track new medical developments. A rural business could set up an on-line forum to distribute information on new products, announce upgrades to existing products, and publish responses to questions from customers. A sheriff's deputy could query an on-line database to determine if a driver that had been stopped had a criminal record or any outstanding warrants. Rural libraries could allow citizens to locate and access a wealth of information in electronic formats rather than in hard copy or other physical formats.

Depending on the type of information and speed of response desired, a remote access application may make use of low-, medium-, or high-speed computer networking services. Some users might find the performance of a low-speed computer networking service inadequate for transferring files, browsing multimedia World Wide Web documents, or running an interactive program on a remote host computer. As the number of users accessing remote resources from a single location (a rural high school, for example) increases, the number or capacity of access circuits must also increase to maintain an adequate level of service.

2.4.3 Distance Learning

Distance learning can take several forms. The classic form links a distant instructor by live video to a class of students; sessions are regularly scheduled. Another form links a subject matter expert by live audio or video to a class of students for a special interactive session, perhaps involving a demonstration from a laboratory or field project. A third form links teachers and students at different locations to exchange information or work together on a common project. Yet another form allows students to use material prepared in advance by an instructor and stored electronically for later retrieval (i.e., prerecorded audio or video programs).

Distance learning capability could enable rural high school students to take foreign language classes not normally offered by local faculty. A rural physician could observe a new surgical procedure without making a trip to a university hospital that could be several hundred miles away. Rural businesses and governments could bring training to employees rather than sending employees to distant urban centers for training.

The different forms of distance learning make use of many different telecommunication services. Any of the voice or video telecommunication services identified in Sections 2.1 and 2.3 could provide some level of distance learning capability. The broadcast-quality video conferencing and interactive video services, however, facilitate closer approximation of live classroom interaction between a teacher and students.

2.4.4 LAN Interconnection

Most organizations operate with the assistance of computers, and in many cases network these computers locally to enhance productivity. If an organization operates from more than one

location, it is to its advantage to link its LANs together. LAN interconnection allows users to access and circulate information throughout an organization.

Interconnected LANs could allow teachers, students, and administrators throughout a rural school district to exchange electronic mail and share data, software applications, and computing resources. Employees of a rural business could enjoy the same benefits if their LAN were interconnected with LANs at other corporate locations. LAN interconnection capability could make a rural area more attractive as a location for a new business. Government offices in rural areas could enhance information exchange with their counterparts in other areas, either rural or metropolitan.

LANs typically operate at transmission speeds ranging from 4-100 Mbps. If inter-LAN traffic is light, low-speed computer networking service may be adequate for interconnection, but it is generally more effective to use medium-speed or high-speed computer networking service. If inter-LAN traffic involves frequent database queries, large file transfers, and heavy client-server interaction, very high-speed computer networking service may be needed.

2.4.5 Electronic Commerce

Common business functions such as placing and taking orders, shipping products, and billing customers have traditionally entailed the transfer and processing of paper documents. Electronic commerce involves the exchange of information via facsimile machines, terminals, computers, and telecommunication networks. Many of the transactions are automated. By reducing or eliminating the prolonged and often error-plagued paper trail, businesses are able to gain a competitive advantage by streamlining transactions with their suppliers and customers. According to the Committee on Applications and Technology of the Information Infrastructure Task Force (NIST, 1994),

> An advanced national electronic commerce capability will be comprised of interconnected communications networks; advanced computer hardware and software tools and services; established business transaction, data exchange, and interoperability standards; accepted security and privacy provisions; and suitable managerial and cultural practices. This infrastructure will enable diverse and distributed companies throughout the nation to rapidly, flexibly, and securely exchange and, more importantly, use information to drive their business processes.

Electronic commerce capability could enable rural businesses to

- authorize credit card purchases or transfer funds electronically.
- negotiate with distant suppliers and customers quickly via facsimile, electronic mail, or video conferencing.
- order material and supplies automatically when inventories run low.
- reach distant markets by advertising and taking orders over the Internet.

Users can acquire different levels of electronic commerce capability using a variety of telecommunication services. Facsimile transmission requires only a low-speed computer networking service, while exchanging electronic documents containing text and complex diagrams

is better suited to a medium-speed computer networking service. Troubleshooting a difficult quality control problem might call for a broadcast-quality video conferencing service to connect several involved parties.

2.4.6 Electronic Government

Electronic government overcomes barriers of time and distance to conduct business efficiently and provide public information and services when and where constituents want them. It can swiftly transfer funds, answer questions, collect and validate data, and keep information flowing smoothly within and outside government. Today's information technologies make possible the creation of "virtual agencies" that provide access to integrated program information and services organized around particular themes (e.g., unemployment assistance), rather than bureaucratic structures. In a virtual agency, several interconnected intergovernmental agencies will be able to provide information and services in a seamless manner (NIST, 1994).

Joseph Wiencko, Jr., Project Manager for the Blacksburg Electronic Village in Virginia, identifies several services that a rural electronic government could offer (1993):

- Establishment of an "electronic town hall" in which people can communicate informally with each other and with town leaders by electronic mail to facilitate civic service and community improvement projects.

- Electronic bulletin boards and electronic conferences to inform citizens about current and future town events, town improvement plans, and ideas for future activities, and to allow each citizen a voice in discussing the relative merits of particular ideas and approaches.

- On-line processing of various registrations, permits, and licenses.

- Distribution of town meeting minutes and other civic information without the delays and expense associated with printing and mailing.

As with other rural information applications, a wide range of telecommunication services could be used to support electronic government. These include two-way and multiple-way voice, low-speed to high-speed computer networking, video on demand, and interactive video.

2.5 Summary

The telecommunication services listed in Sections 2.1 through 2.3 enable a variety of information applications that can help rural areas overcome the barriers of distance and space that disadvantage them. The discussion of applications in Section 2.4 is meant to be illustrative rather than exhaustive; creative users are constantly devising new ways to apply information technology.

It is useful, however, to compare the telecommunication services used by the various applications to see which services are used most often. Table 2-1 provides such a comparison.

Table 2-1. Telecommunication Services Used by Rural Information Applications

Telecommunication Services	Electronic Mail	Remote Access	Distance Learning	LAN Interconnection	Electronic Commerce	Electronic Government
Two-way Voice, Fixed			✔			✔
Two-way Voice, Mobile/Portable			✔			✔
Multiple-way Voice Teleconferencing			✔			✔
Multiple-channel Audio Programming			✔			
Low-speed Computer Networking, Fixed	✔	✔		✔	✔	✔
Low-speed Computer Networking, Mobile/Portable	✔	✔			✔	✔
Medium-speed Computer Networking	✔	✔		✔	✔	✔
High-speed Computer Networking	✔	✔		✔	✔	✔
Very High-speed Computer Networking	✔	✔		✔		
Video Conferencing, Lossy			✔		✔	
Video Conferencing, Broadcast Quality			✔		✔	
Multiple-channel Video Programming			✔			✔*
Video on Demand		✔	✔			✔
Interactive Video		✔	✔			✔

* An electronic government could make use of perhaps one or two channels of a multiple-channel video programming service to broadcast community information, city council meetings, public hearings, etc.

Table 2-1 shows that no service supports all applications, though a fixed low-speed computer networking service will support a low level of capability for many applications. It is clear that to support a range of important and beneficial information applications, rural users require access to many different kinds of telecommunication services. Sections 3 and 4 of this report explore various wireline and wireless technologies that can be used to deliver these services.